

CLAIMS

What is claimed is:

1. A small-gauge optical element comprising:

5 a polymer matrix; and

a plurality of microbubbles displaced within the polymer matrix,

wherein the small-gauge optical element is optically coupled to receive a light beam from a light source and to scatter the light beam to illuminate a surgical field.

10 2. The small-gauge optical element of Claim 1, wherein the small-gauge optical element further comprises circular or semi-ellipsoidal incident surfaces.

15 3. The small-gauge optical element of Claim 1, wherein the small-gauge optical element is sized between 18 and 30 gauge and wherein the small-gauge optical element is optically coupled to an optical fiber for receiving the light beam.

4. The small-gauge optical element of Claim 3, wherein the optical fiber gauge is equal to the gauge of the small-gauge optical element.

20 5. The small-gauge optical element of Claim 3, wherein the small-gauge optical element and the optical fiber are housed within a cannula.

6. The small-gauge optical element of Claim 5, wherein the cannula is operably coupled to a handpiece.

7. The small-gauge optical element of Claim 6, wherein the small-gauge optical element, the cannula and the handpiece are fabricated from biocompatible materials.

5 8. The small-gauge optical element of Claim 6, wherein the optical fiber is optically coupled at one end to the small-gauge optical element and at the other end to an optical cable, wherein the optical cable is operably coupled to the light source to transmit the light beam to the optical fiber, and wherein the optical cable comprises a first optical connector operably coupled to the light source and a second optical connector operably coupled to the handpiece.

10 9. The small-gauge optical element of Claim 8, wherein the optical cable gauge is equal to the gauge of the optical fiber.

15 10. The small-gauge optical element of Claim 8, wherein the optical cable comprises a plurality of optical fibers.

11. The small-gauge optical element of Claim 8, wherein the first and second optical connectors are SMA optical fiber connectors.

20 12. The small-gauge optical element of Claim 5, wherein the optical fiber is operably coupled to the handpiece to enable linear displacement of the optical fiber and the small-gauge optical element within the cannula.

13. The small-gauge optical element of Claim 12, wherein the handpiece further comprises a means for adjusting the linear displacement.

14. The small-gauge optical element of Claim 13, wherein the adjusting means comprises a push/pull mechanism.

15. The small-gauge optical element of Claim 13, wherein a distal end of the small-gauge optical element is co-incident with an open aperture of the cannula.

10 16. The small-gauge optical element of Claim 15, wherein adjusting the linear displacement adjusts the small-gauge optical element position relative to the open aperture by an amount corresponding to the change in linear displacement.

15 17. The small-gauge optical element of Claim 16, wherein the amount of linear displacement of the small-gauge optical element determines an angle of illumination and an amount of illumination from the light beam provided to illuminate the surgical field.

20 18. The small-gauge optical element of Claim 17, wherein the angle of illumination can be varied between about 20 degrees to greater than about 180 degrees.

19. The small-gauge optical element of Claim 1, wherein the light beam comprises a beam of spatially and temporally incoherent light having a broad spectral bandwidth.

5 20. The small-gauge optical element of Claim 1, wherein the light source further comprises one or more optical filters to selectively illuminate the surgical field with different colors of light, such as to excite a surgical dye.

10 21. The small-gauge optical element of Claim 1, wherein the light source is a xenon or halogen light source.

22. The small-gauge optical element of Claim 1, wherein the polymer matrix is closely index-matched to an environment of the surgical field.

15 23. The small-gauge optical element of Claim 22, wherein the environment is the interior of an eye.

24. The small-gauge optical element of Claim 1, wherein the plurality of microbubbles is randomly distributed within the polymer matrix.

20 25. The small-gauge optical element of Claim 1, wherein the plurality of microbubbles each have a diameter of about 1 to 50 microns.

26. The small-gauge optical element of Claim 1, wherein the plurality of microbubbles is distributed with a distribution density operable to scatter and transmit the light beam in an isotropic manner.

5 27. The small-gauge optical element of Claim 1, wherein the polymer matrix is manufactured from one of the group of clear optical grade epoxy resin, uv curable optical adhesive, uv curable resin, glass, optically transparent ceramic material and transparent silicone rubber.

10 28. The small-gauge optical element of Claim 1, wherein the microbubbles comprise one of the group of thermally expanding plastic microspheres and gas-filled spheroidal microbubbles.

15 29. The small-gauge optical element of Claim 1, wherein the small-gauge optical element is about 2 millimeters long.

30. A small-gauge, wide-angle illuminator, comprising:

a handpiece, optically coupled to receive a light beam from a light source;

an optical fiber, operably coupled to the handpiece, wherein the optical fiber receives the light beam from the light source;

5 an optical element, optically coupled to a distal end of the optical fiber, for receiving the light beam and scattering the light beam to illuminate a surgical field, wherein the optical element comprises:

a polymer matrix; and

a plurality of microbubbles displaced within the polymer matrix; and

10 a cannula, operably coupled to the handpiece, for housing and directing the optical fiber and the optical element.

31. The small-gauge, wide-angle illuminator of Claim 30, wherein the optical element is a small-gauge optical element comprising circular or semi-ellipsoidal incident surfaces.

15 32. The small-gauge, wide-angle illuminator of Claim 30, wherein the optical element is sized between 18 and 30 gauge.

20 33. The small-gauge, wide-angle illuminator of Claim 30, wherein the optical element, the cannula and the handpiece are fabricated from biocompatible materials.

34. The small-gauge, wide-angle illuminator of Claim 30, wherein the optical fiber is optically coupled at the distal end to the optical element and at another end to an optical cable, wherein the optical cable is operably coupled to the light source to transmit the light beam to the optical fiber, and wherein the optical cable comprises a first optical connector operably coupled to the light source and a second optical connector operably coupled to the handpiece.

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35. The small-gauge, wide-angle illuminator of Claim 34, wherein the optical cable gauge is equal to the gauge of the optical fiber.

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36. The small-gauge, wide-angle illuminator of Claim 34, wherein the optical cable comprises a plurality of optical fibers.

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37. The small-gauge, wide-angle illuminator of Claim 34, wherein the first and second optical connectors are SMA optical fiber connectors.

38. The small-gauge, wide-angle illuminator of Claim 30, wherein the optical fiber gauge and the optical element gauge are equal.

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39. The small-gauge, wide-angle illuminator of Claim 30, wherein the optical fiber is operably coupled to the handpiece to enable linear displacement of the optical fiber and the optical element within the cannula.

40. The small-gauge, wide-angle illuminator of Claim 39, wherein the handpiece further comprises a means for adjusting the linear displacement.

41. The small-gauge, wide-angle illuminator of Claim 40, wherein the adjusting means comprises a push/pull mechanism.

42. The small-gauge, wide-angle illuminator of Claim 40, wherein a distal end of the optical element is co-incident with an open aperture of the cannula.

43. The small-gauge, wide-angle illuminator of Claim 42, wherein adjusting the linear displacement adjusts the optical element position relative to the open aperture by an amount corresponding to the change in linear displacement.

44. The small-gauge, wide-angle illuminator of Claim 43, wherein the amount of linear displacement of the optical element determines an angle of illumination and an amount of illumination from the light beam provided to illuminate the surgical field.

45. The small-gauge, wide-angle illuminator of Claim 44, wherein the angle of illumination can be varied between about 20 degrees to greater than about 180 degrees.

46. The small-gauge, wide-angle illuminator of Claim 30, wherein the light beam comprises a beam of spatially and temporally incoherent light having a broad spectral bandwidth.

47. The small-gauge, wide-angle illuminator of Claim 30, wherein the light source is a xenon or halogen light source.

5 48. The small-gauge, wide-angle illuminator of Claim 30, wherein the light source further comprises one or more optical filters to selectively illuminate the surgical field with different colors of light, such as to excite a surgical dye.

10 49. The small-gauge, wide-angle illuminator of Claim 30, wherein the polymer matrix is closely index-matched to an environment of the surgical field.

50. The small-gauge, wide-angle illuminator of Claim 30, wherein the environment is the interior of an eye.

15 51. The small-gauge, wide-angle illuminator of Claim 30, wherein the plurality of microbubbles is randomly distributed within the polymer matrix.

52. The small-gauge, wide-angle illuminator of Claim 30, wherein the plurality of microbubbles each have a diameter of about 1 to 50 microns.

20 53. The small-gauge, wide-angle illuminator of Claim 30, wherein the plurality of microbubbles is distributed with a distribution density operable to scatter and transmit the light beam in an isotropic manner.

54. The small-gauge, wide-angle illuminator of Claim 30, wherein the polymer matrix is manufactured from one of the group of clear optical grade epoxy resin, uv curable optical adhesive, uv curable resin, glass, optically transparent ceramic material and transparent silicone rubber.

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55. The small-gauge, wide-angle illuminator of Claim 30, wherein the microbubbles comprise one of the group of thermally expanding plastic microspheres and gas-filled spheroidal microbubbles.

10 56. The small-gauge, wide-angle illuminator of Claim 30, wherein the optical element is about 2 millimeters long.

57. A small-gauge, wide-angle illumination surgical system comprising:
a light source for providing a light beam;
an optical cable, optically coupled to the light source for receiving and
transmitting the light beam;
5 a handpiece, operably coupled to the optical cable to receive the light beam;
an optical fiber, operably coupled to the handpiece, wherein the optical fiber is
optically coupled to the optical cable to receive and transmit the light beam;
an optical element, optically coupled to a distal end of the optical fiber, for
receiving the light beam and scattering the light beam to illuminate a surgical field,
10 wherein the optical element comprises:
a polymer matrix; and
a plurality of microbubbles displaced within the polymer matrix; and
a cannula, operably coupled to the handpiece, for housing and directing the
optical fiber and the optical element.

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58. The small-gauge, wide-angle illumination surgical system of Claim 57,
wherein the optical element is a small-gauge optical element comprising circular or
semi-ellipsoidal incident surfaces.

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59. The small-gauge, wide-angle illumination surgical system of Claim 57,
wherein the optical element is sized between 18 and 30 gauge.

60. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the optical element, the cannula and the handpiece are fabricated from biocompatible materials.

5 61. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the optical fiber is an integral part of the optical cable.

10 62. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the optical cable comprises a first optical connector operably coupled to the light source and a second optical connector operably coupled to the handpiece.

63. The small-gauge, wide-angle illumination surgical system of Claim 62, wherein the first and second optical connectors are SMA optical fiber connectors.

15 64. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the optical cable gauge is equal to the gauge of the optical fiber.

65. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the optical cable comprises a plurality of optical fibers.

20 66. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the optical fiber gauge and the optical element gauge are equal.

67. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the optical fiber is operably coupled to the handpiece to enable linear displacement of the optical fiber and the optical element within the cannula.

5 68. The small-gauge, wide-angle illumination surgical system of Claim 67, wherein the handpiece further comprises a means for adjusting the linear displacement.

10 69. The small-gauge, wide-angle illumination surgical system of Claim 68, wherein the adjusting means comprises a push/pull mechanism.

70. The small-gauge, wide-angle illumination surgical system of Claim 68, wherein a distal end of the optical element is co-incident with an open aperture of the cannula.

15 71. The small-gauge, wide-angle illumination surgical system of Claim 70, wherein adjusting the linear displacement adjusts the small-gauge optical element position relative to the open aperture by an amount corresponding to the change in linear displacement.

20 72. The small-gauge, wide-angle illumination surgical system of Claim 71, wherein the amount of linear displacement of the optical element determines an angle of illumination and an amount of illumination from the light beam provided to illuminate the surgical field.

73. The small-gauge, wide-angle illumination surgical system of Claim 72, wherein the angle of illumination can be varied between about 20 degrees to greater than about 180 degrees.

5 74. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the light beam comprises a beam of spatially and temporally incoherent light having a broad spectral bandwidth.

10 75. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the light source further comprises one or more optical filters to selectively illuminate the surgical field with different colors of light, such as to excite a surgical dye.

15 76. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the light source is a xenon or a halogen light source.

77. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the polymer matrix is index-matched to an environment of the surgical field.

20 78. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the environment is the interior of an eye.

79. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the plurality of microbubbles is randomly distributed within the polymer matrix.

5 80. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the plurality of microbubbles each have a diameter of about 1 to 50 microns.

10 81. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the plurality of microbubbles is distributed with a distribution density operable to scatter and transmit the light beam in an isotropic manner.

15 82. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the polymer matrix is manufactured from one of the group of clear optical grade epoxy resin, uv curable optical adhesive, uv curable resin, glass, optically transparent ceramic material and transparent silicone rubber.

83. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the microbubbles comprise one of the group of thermally expanding plastic microspheres and gas-filled spheroidal microbubbles.

20 84. The small-gauge, wide-angle illumination surgical system of Claim 57, wherein the optical element is about 2 millimeters long.